Space Weather Technical Forecast

Issued on Wednesday 27 November 2024 at 12:00 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Moderate to High Solar Activity expected with M-flares likely. G1/G2 Minor-Moderate Geomagnetic Storm expected 28 Nov.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low in the past 24 hours, with the peak activity a C9.5 flare observed at 27/1020 UTC from near AR3911 in the southwest.

There are currently eight numbered and one un-numbered active regions on the visible disc. The largest and most complex regions on the visible disc are AR3905 and AR3906, both in close proximity to each other, and located in the southeast quadrant. Both AR3905 and AR3906 contain moderately-large lead and trailing spots, with AR3906 containing a small delta in its trailer spot. The other region of note is AR3910 located toward the northeast limb, and which appears to contain a large, mature spot, with smaller spots surrounding it. This region gave an M9 flare on 25 Nov. The remaining groups on the disc are smaller and more magnetically simple.

There was one likely Earth-directed CME during the period. A filament eruption starting around 25/2030 UTC close to AR3901 led to an M1.9 flare, marked coronal dimming and associated CME. This has been analysed as Earth-directed with an impact arrival time likely during the UTC morning of 28 Nov (Day 2).

Solar Wind / Geomagnetic Activity: Solar winds as measured by ACE were at Background levels, 340-390km/s. The Interplanetary Magnetic Field, Bt, was Weak throughout, peaking at 7nT. The north-south component, Bz, varied weakly between +6/-6nT. Phi angle was predominantly negative (towards the Sun). Geomagnetic activity was Quiet (Kp 0-2).

Energetic Particles / Solar Radiation: High energy proton flux observed by GOES18 remained at Background levels. High energy electron flux (greater than 2MeV) observed by GOES16 was at Background levels. The associated 24-hour fluence remained well below the Active threshold. The integrated flux observed at 27/0000 UTC was 1.6e6.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is forecast, with further M-class flares likely and a slight chance of isolated X-class flares. The most likely source locations from AR3905, AR3906, or AR3910.

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Solar Wind / Geomagnetic Activity: A CME that left the Sun late on 25 Nov from the southwest disc is likely to affect Earth on Day 2 (28 Nov). Solar wind speeds are currently at Background levels and are expected to remain there at first. A rise to Elevated levels is possible following the CME arrival on Day 2 (Nov 28), before gradually declining by Day 4 (30 Nov) as CME influences begin to wane.

Geomagnetic activity is expected to be mainly Quiet (Kp 0-2) at first. Upon arrival of the CME on Day 2 (28 Nov), G1/G2 Minor-Moderate Geomagnetic Storms are expected, with a slight chance of G3/Strong Geomagnetic Storm intervals. Enhanced conditions are likely to persist into Day 3 (29 Nov), before gradually waning by Day 4 (30 Nov).

Energetic Particles / Solar Radiation: High energy protons are expected to persist at Background levels, with a slight but increasing chance of Solar Radiation storms occurring later in the period, mainly from the large sunspot regions in the southeast. High energy electron flux has been at Background levels and is expected to persist at these levels throughout. The associated 24 hour fluence is expected to persist below the Active threshold.

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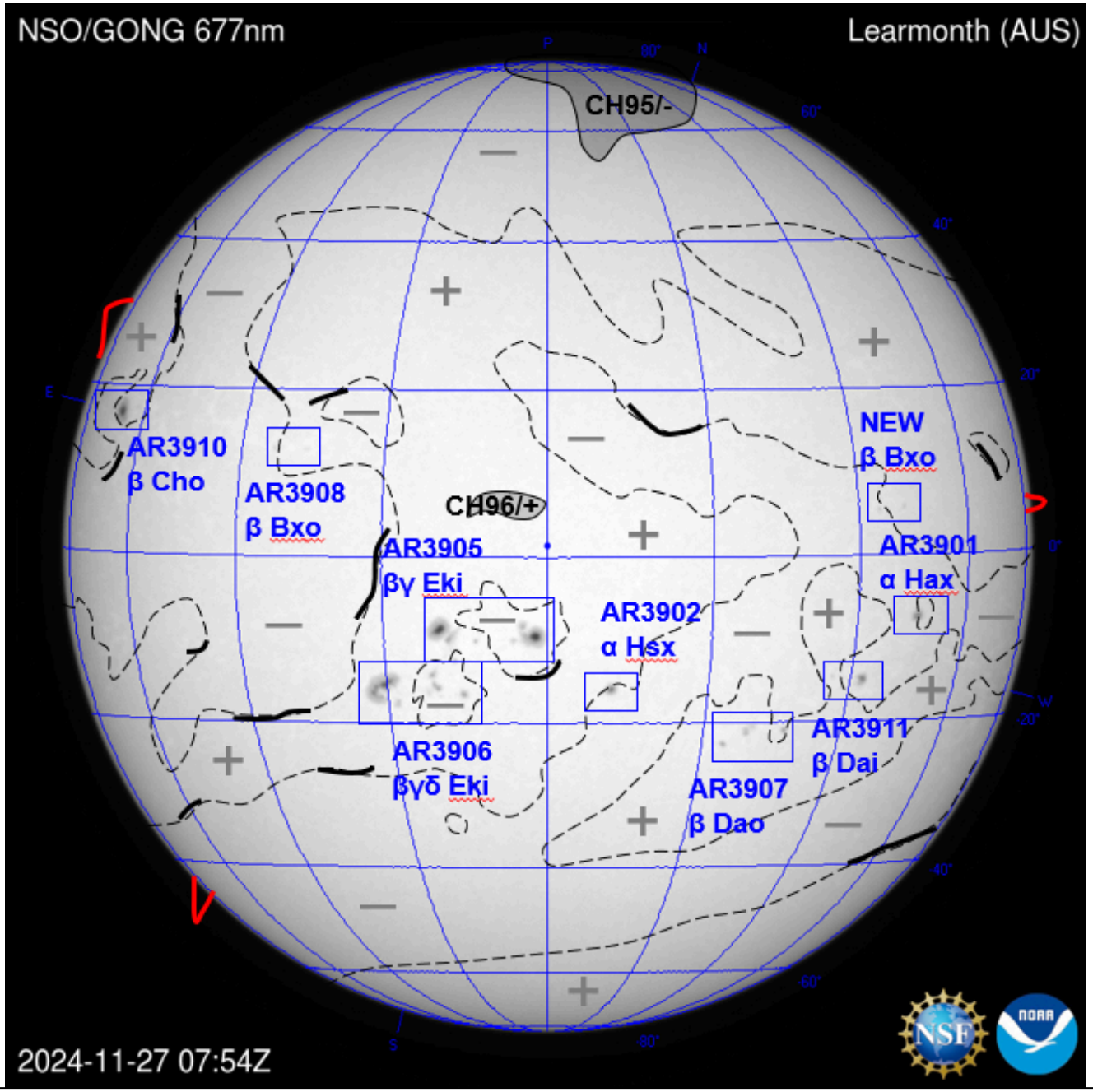
Figure 1: Solar Synoptic Map valid 27/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

Numerous CMEs have left the Sun in recent days, reducing confidence in the analysis of individual events, however, there are considered to be three events of note with potential Earth-directed effects. The first two CMEs left the Sun in quick succession early on 25 Nov from the southeast disc. The first of these has been attributed to the M1.1 flare of AR3906 at 25/0159 UTC, followed by a large filament eruption around 25/0230 UTC. Initial modelling suggests that the bulk, if not all of the ejecta is directed south and east of the Earth-Sun line, however, some slight Earth-directed component and glancing impact from these slow CMEs cannot completely be ruled out to arrive on Day 3 (29 Nov).

Perhaps more significantly, a filament eruption starting around 25/2030 UTC close to AR3901 led to an M1.9 flare and marked coronal dimming, along with a Type II Radio Emission (estimated velocity 490km/s). The bulk of the ejecta from this CME appears to be directed to the southeast, but there is a more halo-like shock visible in imagery. Analysis of this CME suggests an arrival time during the UTC morning of 28 Nov (Day 2).

Solar winds are currently at Background levels following a waning connection to CH94/-, which was located near the southwest limb. Solar winds are expected to remain at Background on Day 1 (27 Nov), likely increasing upon arrival of the forecast CME on Day 2 (28 Nov), perhaps to Elevated levels. No other coronal hole fast wind enhancements are expected through this period. MOSWOC Enlil model output continues to significantly over estimate solar wind speeds, and is considered likely to be too fast until Day 2 (28 Nov) with anticipated CME arrival.

Geomagnetic activity is expected to be mainly Quiet (Kp 0-2) at first. Upon arrival of the CME on Day 2 (28 Nov), G1/G2 Minor/Moderate Geomagnetic Storms are expected, with a slight chance of G3/Strong Geomagnetic Storm intervals. Enhanced conditions are likely to persist into Day 3 (29 Nov), before gradually waning by Day 4 (30 Nov).

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	80	60	10
Strong	G3	No	1	20	10	1
Severe	G4	No	1	5	1	1
Extreme	G5	No	1	1	1	1

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Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
2024-11-25 20:30	Partial	AR3901	SE	950	28/11/2024 07:00 UTC	+/- 7 hours

Figure 2: MOSWOC Enlil model. Note that current wind speeds are being overplayed in the model compared to reality.

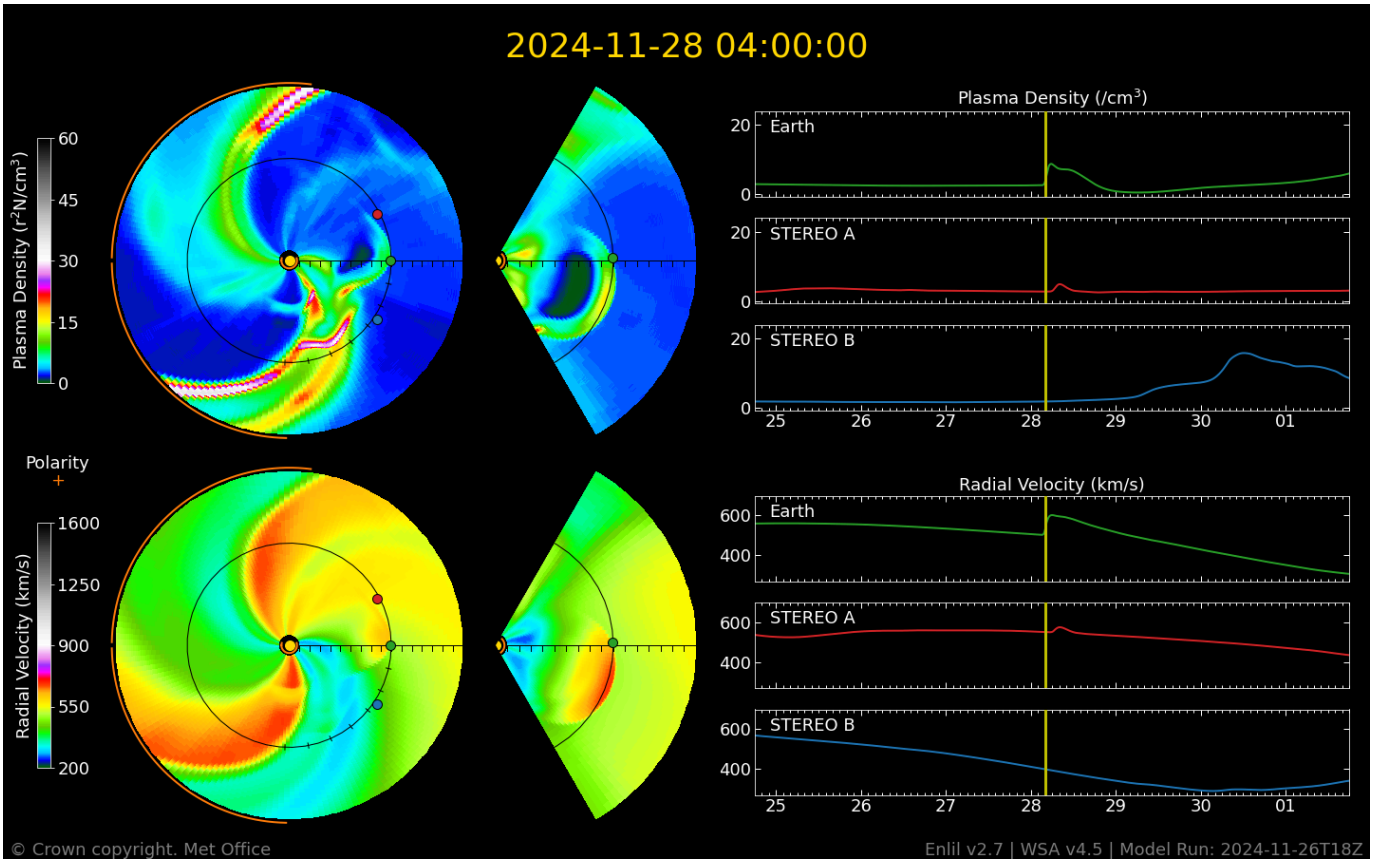

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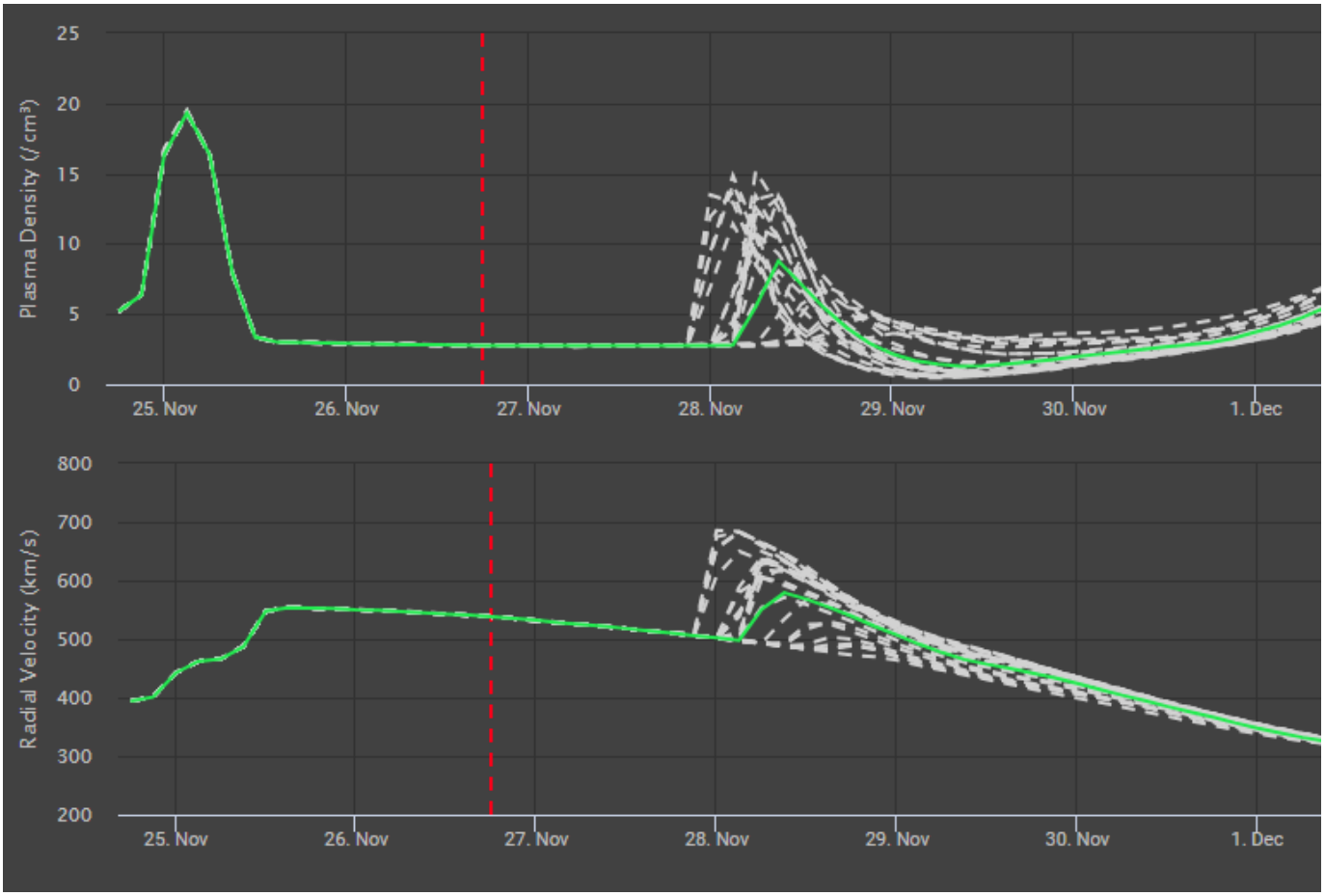
Figure 3: MOSWOC Ensemble model, showing spread of expected CME arrival times.



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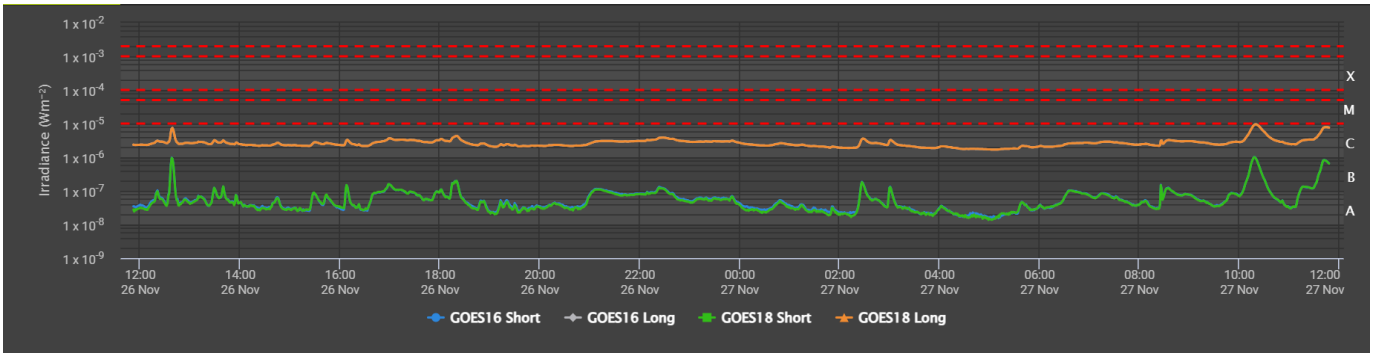
Radio Blackouts - X-Ray Flares

There are currently eight numbered and one un-numbered active regions on the visible disc. The largest and most complex regions on the visible disc are AR3905 and AR3906, both in close proximity to each other, and located in the southeast quadrant. Both AR3905 and AR3906 contain moderately-large lead and trailing spots, with AR3906 containing a small delta in its trailer spot. The other region of note is AR3910 located toward the northeast limb, and which appears to contain a large, mature spot, with smaller spots surrounding it. This region gave an M9 flare on 25 Nov. The remaining groups on the disc are smaller and more magnetically simple.

Solar activity has been Low in the past 24 hours, with the peak activity a C9.5 flare observed at 27/1020 UTC from near AR3911 in the southwest. Low to Moderate activity is forecast, with further M-class flares likely and a slight chance of isolated X-class flares. The most likely source locations from AR3905, AR3906, or AR3910.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	No	70	70	70	70
Very Active	R3-R5 (X Class)	No	15	15	15	15

Figure 4: GOES16/18 X-Ray Flux trace



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Solar Radiation Storms (High Energy Protons)

GOES-18 Proton flux is at Background levels. The main regions currently on the visible disc, which are most likely to produce proton enhancements are AR3905 and AR3906, both located in the southeast quadrant. From this position on the disc any proton enhancements are less likely to significantly affect Earth, but as they rotate towards and then beyond centre disc in the coming days that risk increases marginally. Subsequently, observed proton flux is expected to persist at Background levels, with a slight but increasing chance of Solar Radiation storms occurring later in the period.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons (≥ 2MeV)

Electron flux observed by GOES-16 has been at Background levels and is expected to persist at these levels throughout the period. Some diurnal increases to moderate flux are possible through Day 1 (27 Nov), but electron flux likely to become supressed following the expected CME arrival on Day 2 (28 Nov).

Associated 24 hour fluence is expected to persist below the Active threshold, perhaps with a slight rising trend in the coming days. MOSWOC REFM output thought to be providing reasonable guidance at first, with the indicated rise now thought to be unlikely with the expected CME arrival.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	1	1
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

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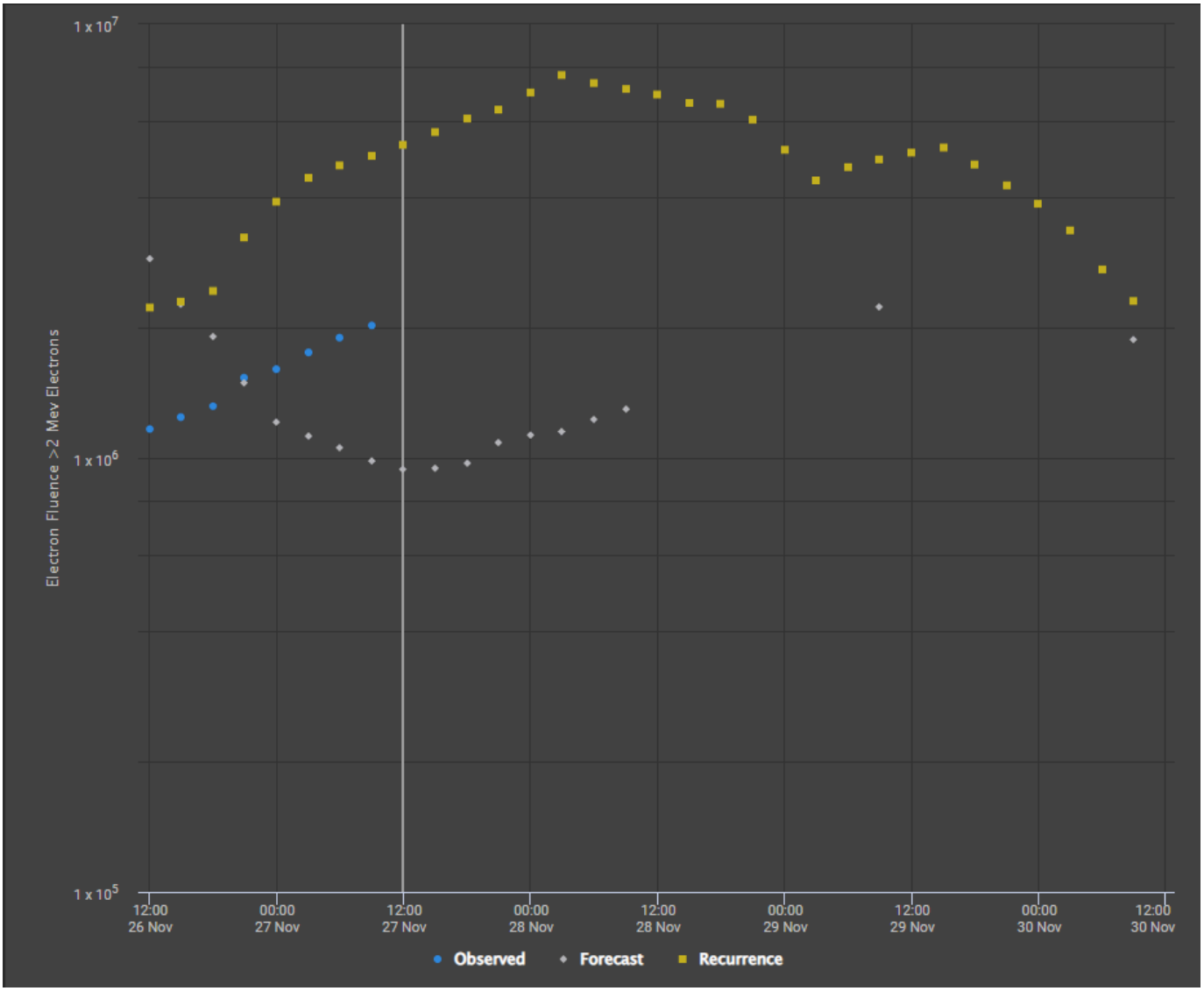
Figure 5: MOSWOC REFM latest



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